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PAVING IN COLD AREAS

MINI-WORKSHOP

October 18-22, 1982

Vancouver, British Columbia

Summary of Proceedings

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17. Abstract

The joint Canada/Japan Paving in Cold Areas Mini Workshop held in Vancouver between October 18 - 22, 1982, brought together Canadian and Japanese experts in the areas of pavement research to discuss the particular problems of paving in cold areas. The workshop consisted of six sessions at which twenty-three papers were presented and one panel discussion took place. The six major topics covered in the workshop were: low temperature cracking; materials and construction to overcome freezing problems in soils; frost penetration and the prevention of frost heaving; the prevention and cure of reflection cracking; characteristics of paving materials; and, additives in asphalts.

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17. Résumé

Un mini-atelier nippo-canadien Les revêtements dans les climats froids s'est tenu à Vancouver du 18 au 22 octobre 1982. Il a regroupé des experts des deux pays dans le domaine de la recherche sur les revêtements et leur a permis de discuter des problèmes particuliers des revêtements dans les climats froids. Cet atelier comprenait six séances, au cours desquelles vingt-trois exposés ont été présentés, ainsi qu'une table ronde. Les six principaux sujets abordés étaient: la fissuration à basse température, les matériaux et les techniques de construction utilisés dans la lutte contre les problèmes de gel dans les sols, la pénétration du gel et la prévention du soulèvement dû au gel, la prévention et l'élimination de la remontée des fissures, les caractéristiques des matériaux de revêtement et les adjuvants du bitume.

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TABLE OF CONTENTS

Acknowledgements		vi
PART I:	Historical Background and Introduction	1
PART II:	Abstracts of Technical Papers	5
PART III:	Conclusions	37
TECHNICAL APPENDICES		
A:	Workshop Program	45
B:	List of Participants	51
C:	Background Document for Field Trip	57
D:	Record of Discussion	79

ACKNOWLEDGEMENTS

The Paving In Cold Areas (PICA) mini-workshop was held in Vancouver, British Columbia on October 18-22, 1982, under the aegis of the Canada/ Japan Science and Technology Consultations.

Recognition and thanks are due to many individuals and agencies that lent their support to the workshop.

The Transportation Development Centre, Transport Canada, financed the workshop and played a pivotal role in helping ensure its success. The Ministry of Transportation and Communications of Ontario published the full workshop proceedings and provided the time and energies of a number of its staff in preparing for this activity. The Public Works Research Institute (PWRI) of the Ministry of Construction of Japan cooperated intensively in the workshop program organization and helped enable the active participation of leading engineers from Japan working in this area. Dow Chemical of Canada Ltd. sponsored the opening reception which gave participants an opportunity to meet informally prior to the workshop and helped set the cooperative and positive tone for the technical activities to come. The Roads and Transportation Association of Canada provided the coordination functions for the workshop.

Primary among the individuals who must be recognized are the Chairman of the workshop, Mr. W.A. (Bill) Phang of the Ontario Ministry of Transportation and Communications, and Mr. Takashi Iijima, PWRI, who organized the Japanese response. In addition, thanks are due Messrs. Don Martin and John Callaghan of the British Columbia Ministry of Transportation and Highways for their excellent work in organizing the field trip. Mr Peter Eggleton of TDC was instrumental in providing direction and guidance to the workshop throughout and, in particular, during the vital closing session. Finally, Dr. John Robinson of RTAC provided the coordination and logistics arrangements needed to ensure the effectiveness of such an activity.

Roads and Transportation Association of Canada, Ottawa

PART I

HISTORICAL BACKGROUND

AND

INTRODUCTION

INTRODUCTION

Canada and Japan convened the first Science and Technology Consultations in 1974 after it was felt by a number of people in both countries that there were real potential benefits to cooperation in specific science and technology areas.

The consultations took place every two years and covered a variety of areas of interest. At the fourth set of such consultations held in Tokyo, June 3-6, 1980, it was agreed that one topic where information exchange and collaborative activity would be of mutual benefit was paving in cold areas.

As a first step in this activity, national contacts were appointed in each of the countries. Canada named Mr. W.A. Phang, Head of Pavement Research at the Ontario Ministry of Transportation and Communications. Japan indicated that this task would be undertaken for their country by Mr. Takashi Iijima, Head of the Pavement Division at the Public Works Research Institute of the Japan Ministry of Construction.

Information exchange was initiated during a visit to Japan by W.A. Phang and I.F. Gilbert of the Transportation Development Centre in November 1980 and was continued during reciprocal visits to Canada by T. Sugawara, S. Matsuno, H. Kubo and H. Ishii at various times in 1981.

The mini-workshop was conceived as a method of extending the depth and scope of the exchange by involving larger numbers of Canadian and Japanese engineers. It was intended that the workshop be a working session, and the following objectives were set out:

1) to exchange information on research and experience in Canada and Japan on the subject of "paving in cold areas",

2) to deepen the understanding of the state of the art and problems associated with "paving in cold areas",

3) to identify needs and opportunities against which research and development should be directed,

4) to identify candidate research projects that can be shared between Canadian and Japanese researchers,

5) to publish proceedings of the workshop.

The format for the workshop consisted of technical sessions involving the presentation of papers. Six separate but consecutive sessions were organized, each covering a different aspect of the problem of paving in cold areas. These are listed below.

Sessions for PICA mini-workshop

Session I - Low Temperature Cracking
Session II - Materials and Construction to Overcome Problems of Freezing in Soils

Session III - Frost Penetration and Prevention of Frost Heave in Pavements
Session IV - Reflection Cracking, Prevention and Cure
Session V - Paving Materials
Session VI - Additive Research

A detailed program of the workshop is included in Appendix A of this summary.

A call for papers was issued in November of 1981, and the final program included twenty-two technical papers plus one panel discussion. In addition, a closing session reviewed the workshop and developed a record of discussions which is presented at the end of this report.

The workshop was financed by TDC, supported by both the Ontario MTC and the PWRI of the Ministry of Construction in Japan, and coordinated by the Roads and Transportation Association of Canada. It was attended by seventeen Japanese and twenty-eight Canadians representing a broad cross section of university, private sector, governmental and regional organizations. A subsequent field trip to the interior of British Columbia, organized by the British Columbia Ministry of Transportation and Highways, allowed participants to visit several test and special sections of highway. These firsthand inspections reinforced the direct knowledge of the techniques in use and being investigated by the British Columbia Ministry to alleviate problems associated with highway paving in cold areas.

In the second section of this summary, the abstracts of all the papers presented at the PICA workshop are included in the order in which they were presented in the program.

A third and concluding section outlines the main results of the workshop, the record of discussions and the directions established for further cooperative efforts in this regard.

Technical Appendices include the workshop program, a list of participants, a technical background paper detailing the test sections visited on the field trip as well as an exact transcript of the record of discussions agreed to by the workshop attendees.

Comments on the publication and/or requests for further information regarding the ongoing program of Canada/Japan consultations with respect to paving in cold areas are welcomed and should be addressed to:

Dr. John B.L. Robinson
Director of Technical Programs
Roads and Transportation Association of Canada
1765 St. Laurent Boulevard
Ottawa, Ontario K1G 3V4
Canada

PART II

ABSTRACTS OF TECHNICAL PAPERS

Note: These abstracts are arranged in exactly the same order and format as they were presented in the original workshop program. This program is reproduced in Appendix A.

SESSION I

Title: Low Temperature Cracking

Presiding Chairman: Ian F. Gilbert
Transport Canada

Technical Papers:

1) Low Temperature Cracking of Asphalt Pavements, Dr. Teruo Sugawara and Dr. Akihiro Moriyoshi, Hokkaido University, and Dr. Hiroshi Kubo, Hokkaido Development Bureau, Japan

2) Low Temperature Cracking of Asphalt Pavements - a Reconsideration, M.A. Laforte, Construction Control and Research Centre, and Dr. J. Hode Keyser, École Polytechnique de Montréal

3) Use of Field Observations and Distress Prediction Techniques to Improve Low Temperature Pavement Cracking Performance, Dr. Ken O. Anderson, University of Alberta

4) Thermally Induced Cracking Due to Hardening of Asphalt Concretes in Airport Asphalt Pavements, Dr. K. Sato, T. Fukute and Y. Hachiya, Port and Harbour Research Institute, Ministry of Transport, Japan

Low Temperature Cracking of Asphalt Pavements

T. Sugawara, H. Kubo and A. Moriyoshi

Abstract

Much transverse cracking has recently been observed in asphalt pavements, even in newly-laid ones, in the severe climatic zone in Hokkaido, Japan. In spite of the mild climatic condition in Hokkaido, the general feature of this type of pavement failure is quite similar to that of transverse low temperature cracking in Canada.

Depending upon the location, the service history and the design of the pavement, transverse cracking frequencies in the range of 10 to 200 cracks per kilometre were most common, and the length of the cracked pavements amounted to 1500 km (12.3% of the total trunk roads) in 1978 in Hokkaido.

The field survey conducted by Hokkaido Development Bureau revealed that the mechanism of this type of cracking is related to the ambient air temperature, the rate of the cooling, the contraction and the stress relaxation property of the paving mixture, the adhesion of the asphaltic layer to the adjacent non-asphaltic layer, the heat capacity of the base, etc.

In the laboratory experimental study started in 1978 at Hokkaido University, the direct thermal fracture test was carried out to investigate the stress-strain relationship during the cooling of the asphalt concrete specimen and the fracture temperature in such a manner that the specimen was virtually constrained to maintain its initial length throughout a range of temperature; then the specimen was subjected to cooling at a programmed rate. In this laboratory work, effects of binder consistency (30 to 400 Pen.), rate of cooling (-3°C to -30°C/h), and initial starting temperature (10°C to -10°C) were investigated. The stress-strain curve was analyzed from a viewpoint of the stress relaxation property of the asphalt concrete, and it was found that the stress-strain curve is composed from two parts of the stress relaxation zone and the non-relaxation zone. This result suggested that the fracture temperature of the asphalt concrete mainly depends on the magnitude of the relaxation zone.

This paper describes findings of the field survey and the laboratory work in Hokkaido, Japan.

SESSION I

PAPER # 2

Low Temperature Cracking of Asphalt Pavements - a Reconsideration

M.A. Laforte and J.H. Keyser

Abstract

Since Rader published his paper on the physical properties of asphaltic materials at low temperature in 1935, several models have been developed to explain low temperature cracking of asphalt pavements. Although asphalt pavements are multilayered systems, most models just take into account the properties of the asphalt layer, as the cracking mechanism of this isolated layer and the influence of the factors involved are generally well defined in the literature.

A number of factors interrelating the other layers are known to influence low temperature cracking. Carpenter, Lytton and Epps indicated that stresses in the non-asphalt treated base layer can cause transverse cracks which ultimately reflect through the surface; Deme and also Hamilton indicated that transverse shrinkage cracks occur in the subgrade and can propagate through the pavement structure by differential movement and be reflected in the pavement surface. All soil engineers practising in cold regions know that non-uniformities in the frost susceptible subgrade can cause differential frost heaving of the pavement resulting in cracking.

Recent studies presented experimental evidence based on the evaluation of two northern roads in Quebec and in Alaska. They showed that, if the existing models are reliable for predicting low temperature cracking of particular sections, they could not be of general application. Keyser and all, for example, are following the performance of 2480 sections of pavement representing 620 km of road running south-north to the James Bay area; this, through continuous evaluation of roughness, strength and surface degradation. The pavement is composed of 10 cm of bituminous overlay made with 300-400 pen asphalt, 15 cm base course and 60 cm subbase. The severity and extent of transverse cracking were counted every 2 years. All the characteristics of the bituminous mixture which are used for crack prediction have been defined during or after the construction. Four models have been evaluated with results obtained four years after the construction, i.e. USCE or Shahin's model, McLeod's model, Haas's model and the Anderson-Christison's model. The need for a more generalized approach was evident through evaluation and the following conclusions were made:

a) Generally speaking, the four models tested worked for 2/3 of the 2480 sections evaluated.

b) For the remaining third, for which the degree of cracking varied widely, the data were analyzed, by correspondence analysis which clearly indicated that for the cracked sections of the road, there is practically no relation between the number

of transverse cracks and the characteristics of the mix used as design parameter in the models.

c) In some sections frost cracks which run through the shoulders account for 1/10 to 1/20 of all transverse cracking.

In this paper, the authors will try:

- to identify the elements of a more general approach to the design of pavement to minimize low-temperature asphalt pavement transverse cracking,

- to give the framework of a more general model which can be used for the development of a design method.

This is done for a typical multilayered system of a flexible pavement.

SESSION I

PAPER # 3

Use of Field Observations and Distress Prediction Techniques to Improve Low Temperature Pavement Cracking Performance

K.O. Anderson

Abstract

Concern over the problems associated with low temperature cracking of asphalt pavements has been reflected by numerous research activities in Canada and the U.S.A., particularly since the early 1960s. Early reports published at that time were supplemented greatly when a symposium on non-load associated cracking was sponsored by the Association of Asphalt Paving Technologists in 1966. Comprehensive reviews of the literature have been published periodically since then; however, it is not possible to further summarize this vast amount of information adequately in the time and space available at this workshop. This paper will be of limited scope with the intention of treating some of the studies in which the author has had some involvement over this period of time. Extensive work of other researchers, such as McLeod and Haas, is recognized but will not be discussed in this paper since their own contributions may be forthcoming.

Most of the report is based upon investigations on the rural highway system of Alberta or on data made available from the Ste-Anne test road in Manitoba. Studies which involve the development of distress prediction models based on this experience such as the COLD program, along with others that help to verify or calibrate the model, will also be briefly described. Work in Alberta was undertaken within the framework of the Alberta Cooperative Highway Research Program, with some support of the later verification phase under an operating grant of the National Research Council of Canada. The damage prediction model referred to as COLD (Computation of Low-Temperature Damage) was developed under the National Cooperative Highway Research Program Project 1-10B by Woodward-Clyde Consultants, San Francisco. The research in Texas was under a cooperative research program through the Texas Transportation Institute at the Texas A & M University, College Station.

Thermally Induced Cracking Due to Hardening of Asphalt Concretes in Airport Asphalt Pavements

K. Sato, T. Fukute and Y. Hachiya

Abstract

Low temperature cracking of asphalt pavements is a serious problem in airports throughout the northern part of Japan. The actual conditions of low temperature cracking in two airports have been investigated. Low temperature cracking is more severe in non-traffic areas such as the edge part of runways and taxiways then in traffic areas. Generally, the aging or hardening of asphalt concrete is faster in non-traffic areas than in traffic areas. This report deals with the effect of the aging of asphalt concrete on low temperature cracking.

Some experiments have been conducted to evaluate the effects of aging on the behaviour of asphalt concrete under thermally induced stresses. In fresh asphalt concrete with no aging, there has been no increase in thermally induced stresses with thermal cycling (-20°C to 10°C, 100 cycles) and no influence on the mechanical properties such as strength and strain at failure. On the other hand, in asphalt concrete with aging, there have been influences on the mechanical properties and the thermally induced stresses.

From these kinds of results, it has been presumed that the aging or hardening of asphalt concrete may have a large effect on low temperature cracking in airport asphalt pavements and the prevention of aging or hardening of asphalt concrete may be a good way to decrease the extent of low temperature cracking.

SESSION II

Title: Materials and Construction to Overcome Problems of Freezing in Soils

Presiding Chairman: T. Iijima
Public Works Research Institute
Ministry of Construction

Technical Papers:

1) Design and Materials Considerations for Cold Climate Pavements, Fred D. Young, Manitoba Department of Highways and Transportation

2) Design, Construction and Maintenance of Asphalt Pavement for Expressways in Cold Areas, S. Kanaya, Y. Kawashima and I. Fukushima, Nihon Doro Kodan

3) The Effects of Freeze-Thaw on the Deformation Properties of Subgrade Soils for Highway and Airport Runways in Cold Regions, Dr. D.E. Pufahl and Dr. Art T. Bergan, University of Saskatchewan

4) Design, Construction and Frost Susceptibility of Lime Stabilized Marine Clay in Highway Subgrade Fill, A. Murray Batten and Alan J. Hanks, Ontario Ministry of Transportation and Communications

Design and Materials Considerations for Cold Climate Pavements

F.D. Young

Abstract

This paper presents an overview of design and materials considerations required for the construction of serviceable pavement in the Province of Manitoba. Ambient temperatures in Manitoba range from 38°C to -43°C, with annual total precipitation equal to approximately 500 mm of rainfall, and we experience between 1700 and 3600 degree days of frost (in Celsius). Soil types range from a CH[(A-7-5)20] to granular, and both well drained and poorly drained land is encountered. Frost penetrations beneath pavements vary from 2.0 to 4.3 m in depth.

As a result of these conditions, structure design and material selection is influenced by the need to maintain low temperature pavement cracking to a minimum, the direction of some efforts towards reduction of reflection cracking and the prevention or minimizing of frost heave.

As a result of research in the late 50s and early 60s, we saw the introduction of soft (SC-3000) asphaltic binders to reduce low temperature transverse cracking. As well, an experimental project in 1958 introduced the first use of foam plastic insulation beneath a pavement. About the same time, the use of a layer of granular base material between existing and new pavements was introduced both to reduce thickness of asphalt pavement overlays and to attempt to eliminate or reduce reflection cracking.

The slow curing asphalt binder successfully eliminated thermal cracking for approximately 10 years, after which time the aging of these pavements provided conditions which allowed considerable cracking, although without the normally experienced decrease in riding comfort. Because of changes in oil reserves, the use of alphalt binders which had been cut back with potential fuels was drastically reduced. This did not pose a problem, however, as the Ste-Anne test road experiment had provided definitive information concerning the role of the asphalt binder relative to thermal cracking and provided the data necessary for the selection of suitable asphalt cements which would reduce thermal cracking potential.

The selection of asphalt cements of higher penetration value and/or higher viscosity characteristics coupled with the use of the gravel base sandwich design has greatly reduced the thermal cracking problem. Experiments incorporating coarse seal coats between old and overlay pavements and some experiments with membranes were also undertaken.

A description of the foamed plastic tests section results is included as well as a description of the insulation of potentially frost heaving soils and of differentially heaving culvert installations.

SESSION II

PAPER # 2

Design, Construction and Maintenance of Asphalt Pavement for Expressways in Cold Areas

S. Kanaya, Y. Kawashima and I. Fukushima

Abstract

Main requirements for surface course mixtures for expressways in cold areas are wear resistance, skid resistance and antiflow characteristics in summer. In Nihon Doro Kodan, to develop appropriate surface mixtures satisfying these characteristics, a series of laboratory tests has been conducted with a traffic simulator and several test pavement sections have been constructed to evaluate the laboratory test results. As a result of these tests, mix design standards for the surface course in cold areas are provided. In the standards, a dense-graded asphalt concrete is adopted and maximum size, gradation and asphalt content are specified.

The materials of pavement and subgrade within the depth of frost penetration have been selected as unsusceptible to frost.

The surface mixtures for cold areas contain less coarse aggregates, and a little more filler and asphalt than those in warm areas.

Regarding surface conditions, rutting has generally become a serious problem on expressways. Especially in cold areas, the increment of rutting by studded tires and tire chains in winter is found to be four times greater than that in warm areas, and frequency of rehabilitation is twice that in warm areas.

With the extension of expressways in cold areas, the frequency of rehabilitation is anticipated to increase and the expenditure of rehabilitation will become a serious problem. Recycling of pavement is expected to be effective and an experimental project has been carried out to reduce the expenditure of maintenance and rehabilitation.

SESSION II

PAPER # 3

The Effects of Freeze-Thaw on the Deformation Properties of Subgrade Soils for Highway and Airport Runways in Cold Regions

D.E. Pufahl and A.T. Bergan

Abstract

Climatic conditions of the north central portion of North America are largely responsible for the seasonal variations that occur in the deflection of pavement structures when they are subjected to heavy wheel loads. Typically, deflections are small during the winter months when the subgrade is frozen. Moderation of the weather during the months of April and May causes thawing of the base, subbase and subgrade material, which in turn results in increased deflections, high stresses and reduced pavement life. As the summer season progresses, the subgrade materials gradually regain their stiffness, thereby reducing deflections and improving the performance of the pavement structure.

The changes in subgrade stiffness, as quantified by the resilient modulus, are due largely to changes in moisture content, to moisture movement, to the development of a secondary soil structure and to the resulting changes in soil matric suction.

Various studies at the University of Saskatchewan and the Saskatchewan Department of Highways have provided a substantial amount of data that clearly indicate the role of freeze-thaw cycles in producing this moisture movement and the concomitant change in soil properties. It is apparent that two or three cycles of freeze-thaw cause the formation of a pronounced secondary soil structure that appears to subsequently control the behaviour of these fine grained subgrade soils. Although the global water content of the soil may remain essentially unaltered, moisture movement within the soil mass is responsible for decreases in metric suction and the resulting decreases in resilient modulus. These results are illustrated and the data is reviewed in this paper. In addition, the variables controlling the behaviour of partially saturated fine grained soils are described. Some recent methods for measuring soil metric suction in the laboratory and field are considered, so that the input parameters to the constitutive equations can be more adequately quantified. Finally, some statements are made concerning the maturity of these aspects of subgrade design, and recommendations are provided for further experimentation.

SESSION II

PAPER # 4

Design, Construction and Frost Susceptibility of Lime Stabilized Marine Clay in Highway Subgrade Fill

A.M. Batten and A.J. Hanks

Abstract

A large quantity of wet, soft, silty clay was modified with a low (1.5 to 2%) mixture of hydrated high calcium lime in conjunction with freeway cut/fill grading operations in the Ottawa area. The natural clay derives from a marine saline deposit known locally as Leda Clay. In the project area the in situ moisture and sensitivity of the clay were such that it was unsuitable for conventional roadway fill construction.

During construction, the addition of lime dramatically strengthened the soft clay, allowing conventional production rates of fill construction within the problem area. The modified clay was placed up to the subgrade level. Excellent fill stability and compaction conditions were achieved. In order to strengthen the subgrade through the cut areas, a 500 mm depth of the subgrade was modified with a higher (5 to 6%) lime content. This section was insulated with a 25 mm thickness of polystyrene board in consideration of the frost susceptibility of the underlying poorly-drained, soft, silty clay subsoil.

In the first winter after completion of the pavement and opening to traffic, the sections over the modified fill construction developed severe distortions due to differential frost heaving. The magnitude of the distortions was such that the driving lanes of the freeway had to be closed for a considerable period.

This paper outlines the design-site and laboratory-investigation analysis, the construction procedures and test data, the performance of the roadway including related climatic data, the site investigation during and after the frost heaving, remedial measures to restore the roadway and follow-up laboratory testing and evaluation to determine causes of the unexpected frost action. Detailed test procedures and data are provided. As well, the paper discusses and recommends design and construction procedures to be used on projects with similar soft clay problems where lime modifications may be an advantage. Direct frost heave measurement tests on prepared specimens of the modified soil proposed for fill construction are recommended.

SESSION III

Title: Frost Penetration and Prevention of Frost Heave in Pavements

Presiding Chairman: Dr. Saburo Matsuno
Kanazawa University

Technical Papers:

1) Measurement and Prediction of Frost Penetration in Highways, R.A. Chisholm and William A. Phang, Ontario Ministry of Transportation and Communications

2) Frost Heave Preventing Measures in Road Pavements, Dr. Hiroshi Kubo, C.E.R.I., Hokkaido Development Bureau

3) The Val Gagne Pavement Insulation Experiment, T.M. Louie, Dow Chemical Canada Inc., and W.A. Phang and R.A. Chisholm, Ontario Ministry of Transportation and Communications

4) The Use of Cold-Mixed, Cold-Laid, Open-Graded Pavement to Minimize Transverse Cracking, W.H. MacDonald, District Municipality of Muskoka, and D.F. Lynch and J.A. Cooper, Ontario Ministry of Transportation and Communications

Measurement and Prediction of Frost Penetration in Highways

W.A. Phang and R.A. Chisholm

Abstract

Knowledge of the depths of frost penetration in highway roadbeds is essential to determining the safe location of structural foundations, sewers, pipelines and watermains. To a great extent, current knowledge of frost penetration is the result of sparsely-documented experience gained from studies on boreholes and excavations, although a method of prediction exists which relates frost penetration to air freezing index.

Through a five-year program of measuring frost depth by use of frost depth indicators at 62 locations in Ontario, a body of data has been acquired and used to make the frost penetration versus air freezing index relationship more appropriate to Ontario. To further assist the user of this relationship, a freezing index map of the province has been created from published temperature data, observed at 224 locations during the period from 1941 to 1970. The map was prepared using a method recently developed by the National Research Council of Canada which calculates the air freezing index from mean monthly temperatures.

While the method is simple to use, certain local factors such as soil type and moisture content influence the actual depth of frost penetration. To enable such effects to be evaluated, and to provide the capability of examining the effects of insulation and frost retaining layers, a computerized solution of the heat flow relationships was developed for the Ministry by Carleton University. The program is able to predict the maximum frost penetration and ground temperatures from input information which is, in most cases, readily available. Computer predictions at several sites have been favourably compared with measurements of actual frost penetration/time profiles.

Frost Heave Preventing Measures in Road Pavements

H. Kubo

Abstract

In snowy and cold areas, road pavements, concrete tunnels and retaining walls are greatly affected by freezing and thawing of the earth. Especially in Hokkaido, and in warmer mountainous areas, frost heave in road pavements causes serious consequences.

The frost heaving occurs when ice crystals grow in the freezing direction and, thus, cause the earth surface to heave. The phenomenon causes damage in two forms: one is due to the frost heaving itself, while the other arises from a decrease in the bearing capacity of the subgrade and subbase in pavements during the spring period. A large number of heavy vehicles cause partial rutting and alligator cracking in asphaltic pavements, while drainage is obstructed by the frozen underlayers in the spring.

The structure of asphaltic pavements is designed with consideration of the number of heavy vehicles, the design CBR of subgrade soil and the depth of frost penetration in pavements in cold regions. In order to protect pavements from frost-heaving damages, the displacement, heat insulation, soil stabilization, and the installation of impermeable layers have been selected as countermeasures, both experimentally and for practical purposes.

For reasons of economy, performance and experience, the replacement method is now generally used for road pavements in Japan. This method consists of replacing frost-susceptible soil with coarse materials to approximate 70% of the theoretical maximum frozen ground in winter.

The Bibi Test Road has been established on National Highway No. 36 in the Tomakomai district, Hokkaido, for the purpose of conducting systematic studies for countermeasures against frost heave damages in the cold areas and to make contributions to theoretical analysis of asphaltic pavements.

This paper will describe the case history of the design method to avoid frost-heaving damages on roads in Hokkaido, and will show a frost-preventing method based on the results of the Bibi Test Road and other field tests with the use of insulation in the pavement structures.

SESSION III

PAPER # 3

The Val Gagne Pavement Insulation Experiment

T.M. Louie, W.A. Phang and R.A. Chisholm

Abstract

Since the first successful treatment of a frost heave problem in 1966 using Styrofoam* HI brand extruded polystyrene foam insulation, Ontario has used substantial quantities of insulation. However, knowledge of the performance of the insulation has been limited to sparsely documented observations of some differently insulated sites. In 1972 a joint experiment was launched by the Ministry and the Dow Chemical Inc. to construct, instrument and observe the performance of pavement insulation at Val Gagne in Ontario.

Three thicknesses of insulation were used in the experiment, and four different taper designs. Winter temperature profiles, frost penetration depths and frost heave measurements were observed during the winters of 1973 to 1977. The results of these observations were used to verify a two-dimensional finite element heat flow computer program intended for use in the design of insulation for controlling frost penetration. While the program accurately predicts ground temperature for uninsulated situations and thin insulated sections, changes in the program are needed to correct inaccuracies in prediction for thick insulations.

The results were also used in the development of a set of frost penetration prediction curves under various thicknesses of insulation and at locations with different degree-days of freezing temperatures. These curves may be used to select the appropriate insulation thickness for any acceptable depth of frost penetration.

Styrofoam insulation recovered from the test site after five years shows virtually no structural changes or changes in thermal properties.

* Trademark of the Dow Chemical, now called Dow Chemical Canada Inc.

The Use of Cold-Mixed, Cold-Laid, Open-Graded Pavement to Minimize Transverse Cracking

W.H. MacDonald, D.F. Lynch and J.A. Cooper

Abstract

The advent of new equipment and the development of new sophisticated asphalt emulsions now permits the construction of cold-mixed, cold-laid open-graded pavements with some degree of success.

This paper outlines the success that the District Municipality of Muskoka in Northern Ontario has experienced with open-graded pavements. Particular reference is made to pavement performance with respect to minimizing low temperature cracking in an area where winter temperature reaches a low of -45°C; the average number of days of below freezing temperature is 145, with an average snowfall of 365 cm.

Over the past five years the District has found that open-graded pavement is much more flexible than any other type of pavement. The open-graded structure and thick asphalt films on the aggregate allow the pavement to conform to deformations without cracking. Resiliency and resistance to cold temperatures remain over a considerable length of time and provide added flexibility and self-healing to the pavement.

A brief outline of design, construction procedures, observations and cost is included.

The District has achieved such good results that it is planning to continue the construction of open-graded pavements on an annual basis.

SESSION IV

Title: Reflection Cracking, Prevention and Care

Presiding Chairman: Fred D. Young
Manitoba Highways and Transportation

Technical Papers:

1) Preventing Reflection Cracking, J. Bev McMaster and W.E. Blum, Ontario Ministry of Transportation and Communications

2) Paving Maintenance, Rehabilitation and Reflection Crack Prevention Methods, Takashi Iijima, P.W.R.I., Japan Ministry of Construction, and Dr. Saburo Matsuno, Kanazawa University

3) Overlaid Maintenance Test Section - 1975, R. Bill Culley and Gary H. Heiman, Saskatchewan Highways and Transportation

4) Sealing Cracks in Flexible Pavements in Cold Areas, George J. Chong, Ontario Ministry of Transportation and Communications

SESSION IV

PAPER # 1

Preventing Reflection Cracking

J. B. MacMaster and W.E. Blum

Abstract

As new pavements age, cracking develops almost without exception. The type, frequency and severity of cracking is related to various factors which include design parameters, materials and environment. The serviceability of a roadway may, in time, be adversely affected, particularly by the environment, as a result of such cracking. Riding comfort declines, user costs rise, driver safety may be jeopardized and, indeed, the structural integrity of the highway could be in peril if some form of rehabilitation is not carried out.

One of the most common methods of restoring the serviceability level of a highway is to apply an asphalt concrete overlay. Unfortunately, the formation of reflection cracks often results in a premature decline in the design life of the overlay. This problem is compounded in seasonal frost areas due to the freezing of moisture which enters the pavement structure through these cracks.

In this paper, the authors illustrate briefly how reflection cracking in Ontario is influenced by the factors mentioned above. A review is carried out of various methodologies and techniques which the Ministry has employed in recent years, to minimize reflection cracking in overlays. Details are given on the use of modified asphalt mixes as binder courses. These mixes are open graded in nature and have been placed over flexible and rigid pavements. Trials have been implemented utilizing variable overlay depths on different types of pavements. The Ministry's experience with geotextiles used for overlay reinforcement purposes is also summarized.

Conclusions are drawn about the most effective and economically viable treatments that have been tried. Recommendations are given with respect to the use of new methodologies, techniques and materials by M.T.C. in future efforts to prolong pavement life and protect the investment made in Ontario's highway system.

SESSION IV

PAPER # 2

Paving Maintenance, Rehabilitation and Reflection Crack Prevention Methods

T. Iijima and S. Matsuno

Abstract

The present state of techniques used to prevent reflection cracking in Japan is described and the use of fabric sheets as a preventive technique is evaluated in this report.

1/ The present state of preventive techniques for reflection cracking.

The design and construction procedures of asphalt concrete overlay for existing asphalt and cement concrete pavements are described in the "Road Maintenance Manual", the outline of which is as follows.

- Overlay on existing asphalt concrete pavements.

  Two thickness design methods, the subgrade CBR method and the Benkelman deflection method, are used in Japan. Prior to overlaying, cracked areas must be treated by patching or planing. Planing is most widely used on heavy traffic roads.

- Overlay on existing cement concrete pavements.

  The overlay thickness is designed using subgrade CBR values, in which 8 cm is recommended for the minimal overlay thickness. To prevent occurrence of reflection cracking, open-graded asphalt concrete is used for binder course, or some kinds of fabric sheets are placed underneath the overlay.

2/ Evaluation of the preventive technique for reflection cracking with fabric sheets.

Two types of fabric sheets are used for this purpose: one is bituminous waterproofing sheets and the other is fabric sheets placed directly on the pavement surface with bituminous adhesives. Both of them have proved to be effective in delaying the appearance of reflection cracks; however, they, so far, have failed in complete prevention. More reliable types of sheets are still in the development stage.

Overland Maintenance Test Section - 1975

R.W. Culley and G.H. Heiman

Abstract

In the early 1970s, the Saskatchewan Department of Highways and Transportation management were evaluating procedures that would reduce the initial capital cost of new construction and rehabilitation. An overlay test section was constructed in 1975 with three (3) thicknesses, one section without an overlay, to evaluate the benefit-cost of each alternative. The test section was constructed on the eastbound lanes of a four-lane divided highway with an AADT of 6000 v.p.d. The test section has detailed records of construction cost and maintenance cost. Performance was measured by RCI, Benkelman Beam and Dynaflect deflections and deflection slopes, and condition surveys using aerial photography.

The paper describes the test section, summarizes the performance indicators and gives an economic analysis covering seven (7) years. The results of the performance cost indicators follow classic pavement management models. The cost analysis shows the threshold limits of extensive maintenance by deep patching. The choice of how thick an overlay should be placed will still be made from a trade-off of pavement serviceability versus capital available for the project versus the needs of other projects.

SESSION IV

PAPER # 4

Sealing Cracks in Flexible Pavements in Cold Areas

G.J. Chong

Abstract

Crack sealing has had a rather checkered (on-again, off-again) history in our Ministry (MTC). In many instances in the past, crack sealing was demonstrated to be ineffective due to both application procedures and materials available at the time.

The materials with which MTC has had such poor previous experience for crack sealing are the RS-type emulsions combined with sand or crushed stone chips. Usually, the result is ineffective because very little emulsion is able to penetrate the crack to effect a seal. Chance of success is not enhanced by the fact that crack sealing by this method is generally carried out in the summer when all the cracks are at their closed position.

However, the consequences of leaving cracks untreated to permit entry of water and brime from road salt can be severe. Premature deterioration, loss of functional serviceability, more extensive maintenance requirements and decreased useful life are certain to occur.

In the summer, rainwater will enter the pavement structure through pavement cracks and tend to saturate the granular base and subbase. The excessive moisture will cause pumping under traffic with resultant loss of structural integrity at, and immediately adjacent to, the crack. Net results can be development of multiple cracking or spalling.

During winter months, large quantities of brime solution from road salting are available for entry into the pavement structure through the crack which is now opened wider than in summer. Because of the lower freezing point of the saline solution which allows it to penetrate into the granular base, differential heaving usually results, causing the crack not only to open but to cup or lip as well. This cupping or lipping causes very rough ridability of the pavement surface in winter and a residue is quite common after the heave subsides during the spring and summer months. Even more drastic problems such as pot-holing will occur if preventive maintenance action is not taken.

Well-timed preventive maintenance treatment is necessary to prevent all these problems. Crack sealing to waterproof the pavement is the logical solution regardless of past poor experience. Therefore, an effort is being made to search out more effective materials and better application techniques.

Three test sites were set up in 1980 and 1981 to look into performance of sealing materials in field conditions, and examine techniques for the preparation of the crack, rout design, pour methods, and equipment for sealing of pavement cracks by rout and seal. It is expected that the

experiences gained at these and other sites will help to establish maintenance performance standards and materials specifications for crack sealing treatment.

This report describes recent Ontario experiences with the performance of different types of sealant and discusses crack preparation, rout designs, crack filling methods and equipment for routing and sealing.

SESSION V

Title: Paving Materials

Presiding Chairman: Dr. Hiroshi Kubo, C.E.R.I.
Hokkaido Development Bureau

Technical Papers:

1) Low Temperature Properties of Some Selected Bituminous Mixes and Application to Design, Dr. Atsushi Kasahara, Hokkaido Institute of Technology, and Dr. Ralph C.G. Haas, University of Waterloo, Ontario

2) Study on the Abrasion Problem in Japan, Takashi Iijima and Ippei Kojima, P.W.R.I., Japan Ministry of Construction

3) Characterization of Flexible Pavement Components, Dr. John J. Emery, Trow Ltd., Rexdale, Ontario

4) Reinforcement of Asphalt Pavements with a High Strength, Plastic Geogrid, Abdelhalim O. Abdelhalim, Ph.D. Candidate, University of Waterloo, Louise Steele, Pavement Management Systems Ltd., and Dr. Ralph C.G. Haas, University of Waterloo

SESSION V

PAPER # 1

Low Temperature Properties of Some Selected Bituminous Mixes and Application to Design

A. Kasahara and R. Haas

Abstract

The problem of low-temperature cracking of asphalt pavements is severe in many parts of North America and several areas in Japan. As a consequence, researchers in Japan, Canada and the U.S. have carried out a major amount of work on this problem and have made considerable progress.

This paper reports on a combination of such progress made by several Japanese and Canadian researchers, including the authors. First, the key factors which can affect low-temperature cracking are identified and briefly described. They include the type and properties of the bitumen and the temperature conditions appropriate to the site.

A method is presented for characterizing the low-temperature properties of bituminous mixes using a "transition point", which is the peak of the flexural strength vs. temperature curve, represents an equivalent stiffness for all mixes, and represents the transition between brittle and ductile failure.

This transition point correlates well with certain common bitumen properties and this has been used to construct a nomogram whereby fracture temperature can be estimated from these properties.

A comparison has been made between such estimated cracking temperatures and observed cracking temperatures from several investigations. It was concluded that the estimation method provides reasonable answers for design purposes.

An equation for predicting frequency of low-temperature cracking as a function of bitumen stiffness, age of pavement, winter design temperature, subgrade soil type and thickness of pavement has also been presented.

Finally, some of the limitations of current technology have briefly been considered. They include an inability to adequately model all the variables affecting low-temperature cracking and the need for conducting research on the cracking potential of recycled pavements.

SESSION V

PAPER # 2

Study on the Abrasion Problem in Japan

T. Iijima and I. Kojima

Abstract

The inhabitants of Japan are allowed to equip their vehicles with studded tires and, consequently, a serious pavement abrasion problem occurs in winter. A study of this problem was conducted.

The first part of this paper describes the estimation method for pavement abrasion which was made by observing results on real roads from 1977 to 1979. The next part considers the anti-abrasion effect of asphalt binder containing additives, such as rubber, epoxy resin, etc. by using test pavements on national highways. The last part compares the abrasion test methods used in Japan, especially at the regional offices of the Ministry of Construction.

SESSION V

PAPER # 3

Characterization of Flexible Pavement Components

J. Emery

Abstract

The full characterization of flexible pavement components must involve consideration of both structural capacity and drainage requirements. The resilient modulus (M_R) and resilient Poisson's ratio ($_R$) characterization of asphaltic concrete surface and binder course mixes (laboratory prepared specimens and cores of various ages), granular base and subbase aggregates (various types and use categories) and typical subgrade materials is described in terms of equipment development, testing procedures and general results, with a comparison to typical procedures and findings from the literature. Simple diametral resilient modulus equipment was adopted for bound materials, but the importance of confining influences required dynamic triaxial testing for unbound materials. For the base and subgrade materials, the important interacting permeability (k) aspects were also considered, which involved permeability testing of CBR size specimens prepared to conditions representative of field situations. Stress levels and environmental conditions typical to Ontario were adopted.

The research results are summarized, with particular emphasis on the innovative aspects of equipment development and test methods. Key findings, such as aging influences on asphaltic concrete M_R which tend to be greater than differences between mixes, and M_R and k ranges for granular materials, are discussed. It is concluded that the use of dense graded granular bases and subbases may optimize structural capacity, but this is often at the expense of the free-draining behaviour essential to long-term pavement performance.

The research reported was supported by the Ontario Ministry of Transportation and Communications.

SESSION V

PAPER # 4

Reinforcement of Asphalt Pavements with a High Strength, Plastic Geogrid

A.O. Abdelhalim, L. Steele and R. Haas

Abstract

The notion of reinforcing flexible pavements has existed for some years, and a few attempts have been made to use metallic and other materials. These have not been cost and performance effective.

Recently, however, a new, high strength plastic geogrid material known as Tensar has become available and pavement reinforcement was suggested as one of its possible civil engineering applications. Consequently, the first phase of a research program initiated in early 1981 examined the potential of a variety of materials for pavement reinforcement, including Tensar. The conclusion was that this new material did indeed offer potential and should be further evaluated.

An initial material testing program involving polyethylene Tensar was carried out in 1981. The purpose was to determine the stress-strain characteristics of Tensar, for use in predicting its behaviour under varying temperature and loading conditions.

A comprehensive experimental program of "model" tests of reinforced and unreinforced pavements was then carried out in the latter half of 1981 and early 1982. This paper describes the experimental program and the comparative results that were obtained.

Variables in the experiment were different thicknesses of full depth asphalt, reinforced vs. unreinforced sections, and different subgrade strengths. Dynamic, repeated loads to simulate loaded truck traffic were applied and measurements were made of cumulative permanent deformation, static rebound, fatigue cracking, etc. As well, instrumentation was installed to measure dynamic and static tensile strains in the Tensar mesh itself, at the bottom of the asphalt layer and vertical stress in the subgrade on one series of tests.

The results showed that the Tensar mesh was very effective as a reinforcement, in terms of carrying double the number of load repetitions, giving thickness savings between 50 and 100 mm, and minimizing fatigue cracking. Because of this effectiveness, it seems well worthwhile as a next step to develop a field installation/construction technology and carry out full-scale field trials.

SESSION VI

Title: Additive Research

Presiding Chairman: Bill W. Culley
Saskatchewan Department of
Highways and Transportation

Technical Papers:

1) Modified Asphalts in Japan and Research into the Development of New Rubberized Asphalts, Hiroyuki Tada, formerly with the Japan Ministry of Construction, Minoru Makita, Takashi Iijima and Hiroyuki Sakamoto, P.W.R.I., Japan Ministry of Construction

2) RTAC Project - Summary Report on the Study of Additives and Extenders for Asphalt Cements, Dr. Ralph C.G. Haas, Pavement Management Systems, Paris, Ontario, et al

SESSION VI

PAPER # 1

Modified Asphalts in Japan and Research into the Development of New Rubberized Asphalts

H. Tada, M. Makita, T. Iijima and H. Sakamoto

Abstract

In Japan, various kinds of modified asphalts are used for the special requirements of pavement construction, such as resistance to plastic flow and wearing resistance.

But the modified asphalts have become insufficient to prevent plastic flow of pavement in warm areas and wearing of pavement in cold areas because of the increase in traffic and the use of large vehicles in recent years.

This paper describes the present state of modified asphalts in Japan and research on the development of new rubberized asphalt to meet the requirements of resistance to plastic flow and to wearing on recent heavy traffic roads.

Summary Report on the Study of Additives and Extenders for Asphalt Cements

R. Haas, E. Thompson, F. Meyer and G.R. Tessier

Abstract

A number of major asphalt pavement problems continue to exist in Canada. These have significant performance and economic implications. In 1981 the Council on Cooperative Research (CCR) of the Roads and Transportation Association of Canada (RTAC) considered that certain asphalt additives and extenders may offer some help to solving or alleviating these problems.

Consequently, a project on "Study of Asphalt Cement Additives and Extenders" was set up in 1981 by RTAC and funded by the CCR and Transport Canada. This paper summarizes the results of that project report.

The introductory part of this paper briefly describes the project objectives, provides a working definition for additives and states the justification for using these materials.

The paper then identifies the major asphalt pavement problems in Canada, the potential role of additives, the types available and their characteristics. An evaluation procedure follows and it is used to identify the most promising types of additives. The supply-demand situation is briefly considered and, finally, a set of research needs is presented.

PART III

CONCLUSIONS:

Workshop Results, Record of Discussions
and Directions for the Future

CONCLUSIONS

The PICA workshop had three main thrusts. The first and dominant one involved in-depth exchange of technical information. This was accomplished through the presentation of technical papers and aimed at providing those present with an up-to-date summary of the technology of paving in cold areas. These discussions have been summarized in Part II of this report.

Flowing from this, the second element aimed at identifying needs and opportunities for further research and development in this area of concern.

Finally, the third major aim was towards defining specific directions for further cooperative efforts between Canada and Japan on the problem of paving in cold areas in the future.

In the closing session of the workshop, chaired by Mr. Peter Eggleton, Executive Director of TDC, the latter two thrusts were examined and discussed in detail by the workshop participants.

Individual presentations and a round table discussion enabled the preparation of a general list of areas of common interest and possible cooperative research. This list, compiled under four major subject areas, is summarized below.

Additives

- to assist in the control of reflection cracking,
- to control aging,
- to prevent or retard stripping,
- to prevent studded tire wear,
- to enhance or act as recycling agents.

Pavement Management

- the measurement of quality of pavement service and appropriate criteria,
- the automated collection and use of data for decision making in pavement rehabilitation,
- the consideration of preventive maintenance in pavement management.

Low Temperature Effects

- binder specifications for improved performance in low temperature areas,
- low temperature cracking, more specifically treatments to prevent and/or cure effects of reflection cracking such as open graded mixes, and softness of asphalt cement.

- a systems approach considering all of the various factors involved to the phenomenon of low temperature cracking.

Construction and Design

- quality assurance,

- similarities between Canada and Japan for design purposes.

In addition to the above, a high priority was assigned to problems in two theme areas:

i) Reflection Cracking, Causes, Treatment, and Cure, i.e. the study of reflection cracking and treatments to prevent, retard, and/or cure the effects of reflection cracking, including the use of additives in asphaltic binders.

ii) Pavement Management Criteria, i.e. the measurement of quality of service and appropriate criteria for use in decision making in pavement management.

As a result of the discussions, there was a consensus that another PICA workshop, two to three years in the future, would be highly desirable. The intention of the subsequent workshop would be to pursue discussions related to the two priority areas noted above. A possible list of topics was identified as follows:

Prevention and Cure of Cracking in New Pavements and Reflection Cracking

- applications and effectiveness of asphalt additives such as polymers,

- various new techniques and materials,

- mix design and pavement structure design,

- theoretical analysis of reflection cracking,

- timing and materials, methods and equipment for maintaining reflection cracks.

Pavement Management

- measurement of quality of service: the what and how,

- automated data collection and analysis: the why and when,

- criteria for quality of service for various classes of highway,

- timing and methods of preventive maintenance,

- predicting life cycles for various types or methods of pavement rehabilitation,

- budget planning.

It was also agreed that through the designated national contact officers, specific cooperative activities and projects would be identified in more detail. Any projects requiring extensive resource commitments and more formal arrangements would be the subject of Joint Research Project Agreements.

As a concluding note, it is worth reviewing the five objectives set out for the workshop in the context of what was accomplished. For convenience, these objectives (previously seen in Part I) are reproduced once more below.

Objectives of PICA Workshop

1) to exchange information on research and experience in Canada and Japan on the subject of "paving in cold areas",

2) to deepen the understanding of the state of the art and problems associated with "paving in cold areas",

3) to identify needs and opportunities against which research and development should be directed,

4) to identify candidate research projects that can be shared between Canadian and Japanese researchers, and

5) to publish proceedings of the workshop.

The first and second objectives were completely satisfied through the presentation of papers by the workshop participants. The ample time provided for discussion after each paper provided a real opportunity for those present to clarify and question any points they wished. Such exchanges proved as valuable as the presentations themselves, in many instances, in bringing to light areas of particular concern.

The excellent and detailed proceedings produced by the Ontario Ministry of Transportation and Communications, and distributed at the workshop itself, provided a timely and permanent technical record for the participants. This accomplished the fifth goal set out above.

Needs and opportunities for research in the future (objective number three) were successfully identified through the round table discussions during the concluding session, as well as during more informal meetings which took place outside of the scheduled sessions.

Finally, through the particular efforts of Messrs. Phang, Iijima and Eggleton, a general direction for the future was established in keeping with the spirit of the fourth objective. The national contact officers will also pursue more detailed work in this area in the future.

The Mini Workshop on Paving in Cold Areas achieved completely the objectives set out it at its inception. Beyond the defined objectives, it also succeeded in establishing an extremely positive and cooperative atmosphere among the workship participants. Relationships were established between Japanese and Canadian engineers which should progive for long-lasting bonds of friendship and cooperation in the future. This kind of benefit, unquantifiable but basic to any successful collaborative human effort may, in the long run, prove to be one of the most important achievements of all.

TECHNICAL APPENDICES

(A) DETAILED WORKSHOP PROGRAM

(B) LIST OF PARTICIPANTS

(C) BACKGROUND PAPER ON FIELD TRIP

(D) TRANSCRIPT OF RECORD OF DISCUSSION

TECHNICAL APPENDIX A

WORKSHOP PROGRAM

MONDAY, OCTOBER 18 (morning)

7:30-8:30 a.m. - Registration

9:00 a.m. - Session I: LOW TEMPERATURE CRACKING

Opening Session - Ian F. Gilbert, Transport Canada, presiding

Welcome to B.C. - R.G. Harvey, Deputy Minister, British Columbia Ministry of Transportation and Highways

Opening Address - Peter Eggleton, Transport Canada, Transportation Development Centre

9:45 a.m. Low Temperature Cracking of Asphalt Pavements, Dr. Teruo Sugawara and Dr. Akihiro Moriyoshi, Hoddaido University, and Dr. Hiroshi Kubo, Hoddaido Development Bureau, Japan

Low Temperature Cracking of Asphalt Pavements - A Reconsideration, M.A. Laforte, Construction Control and Research Centre, and Dr. J. Hode Keyser, École Polytechnique de Montréal

Use of Field Observations and Distress Prediction Techniques to Improve Low Temperature Pavement Cracking Performance, Dr. Ken O. Anderson, University of Alberta

Thermally Induced Cracking Due to Hardening of Asphalt Concretes in Airport Asphalt Pavements, Dr. K. Sato, T. Fukute and Y. Hachiya, Port and Harbour Research Institute, Ministry of Transport, Japan

12:00 noon - Lunch Break

MONDAY, OCTOBER 18 (afternoon)

1:30 p.m. - Session II: MATERIALS AND CONSTRUCTION TO OVERCOME PROBLEMS OF FREEZING IN SOILS, T. Iijima, P.W.R.I., Japan Ministry of Construction, presiding

Design and Materials Considerations for Cold Climate Pavements, Fred D. Young, Manitoba Department of Highways and Transportation

Design, Construction, and Maintenance of Asphalt Pavement for Expressways in Cold Areas, S. Kanaya, Y. Kawashima and I. Fukushima, Nihon Doro Kodan

The Effects of Freeze-Thaw on the Deformation Properties of Subgrade Soils for Highway and Airport Runways in Cold Regions, Dr. D.E. Pufahl and Dr. Art T. Bergan, University of Saskatchewan

Design, Construction and Frost Susceptibility of Lime Stabilized Marine Clay in Highway Subgrade Fill, A. Murray Batten and Alan J. Hanks, Ontario Ministry of Transportation and Communications

TUESDAY, OCTOBER 19 (morning)

9:00 a.m. - Announcement re: Field Trip Arrangements, Don Martin

Session III: FROST PENETRATION AND PREVENTION OF FROST HEAVE IN PAVEMENTS, Dr. Saburo Matsuno, Kanazawa University, presiding

Measurement and Prediction of Frost Penetration in Highways, R.A. Chisholm and William A. Phang, Ontario Ministry of Transportation and Communications

Frost Heave Preventing Measures in Road Pavements, Dr. Hiroshi Kubo, C.E.R.I., Hokkaido Development Bureau

The Val Gagne Pavement Insulation Experiment, T.M. Louie, Dow Chemical Canada Inc., and W.A. Phang and R.A. Chisholm, Ontario Ministry of Transportation and Communications

The Use of Cold-Mixed, Cold-Laid, Open-Graded Pavement to Minimize Transverse Cracking, W.H. MacDonald, District Municipality of Muskoka, and D.F. Lynch and J.A. Cooper, Ontario Ministry of Transportation and Communications

12:00 noon - Lunch Break

TUESDAY, OCTOBER 19 (afternoon and evening)

1:30 p.m. - Session IV: REFLECTION CRACKING, PREVENTION AND CURE, Fred Young, Manitoba Department of Highways and Transportation, presiding

Preventing Reflection Cracking. J. Bev MacMastr and W.E. Blum, Ontario Ministry of Transportation and Communications

Paving Maintenance, Rehabilitation, and Reflection Crack Prevention Methods, Takashi Iijima, P.W.R.I., Japan Ministry of Construction, and Dr. Saburo Matsuno, Kanazawa University

Overlaid Maintenance Test Section - 1975, R. Bill Culley and Gary H. Heiman, Saskatchewan Highways and Transportation

Sealing Cracks in Flexible Pavements in Cold Areas, George J. Chong, Ontario Ministry of Transportation and Communications

6:00 p.m. - Reception, followed by
7:00 p.m. - Dinner (sponsored by Transport Canada, Transportation Development Centre)

Speaker - Mr. Henry Wakabayashey, Deputy Director and Development Manager, N.E. Coal Development, Vancouver

WEDNESDAY, OCTOBER 20 (morning)

9:00 a.m. - Session V: PAVING MATERIALS, Dr. Hiroshi Kubo, C.E.R.I., Hokkaido Development Institute, presiding

Low Temperature Properties of Some Selected Bituminous Mixes and Application to Design, Dr. Atsuchi Kasahara, Hokkaido Instutute of Technology, and Dr. Ralph C.G. Haas, University of Waterloo, Ontario

Study on the Abrasion Problem in Japan, Takashi Iijima and Ippei Kojima, P.W.R.I., Japan Ministry of Construction

Characterization of Flexible Pavement Components, Dr. John J. Emery, Trow Ltd., Rexdale, Ontario

Reinforcement of Asphalt Pavements with a High Strength, Plastic Geogrid, Abdelhalim O. Abdelhalim, Ph.D. Candidate, University of Waterloo, Louise Steel, Pavement Management Systems Ltd., and Dr. Ralph Haas, University of Waterloo

12:00 noon - Lunch Break

WEDNESDAY, OCTOBER 20 (afternoon)

1:30 p.m. - Session VI: ADDITIVE RESEARCH, R. Bill Culley, Saskatchewan Department of Highways and Transportation, presiding

Modified Asphalts in Japan and Research into the Development of New Rubberized Asphalts, Hiroyuki Tada, formerly with the Japan Ministry of Construction, Minoru Makita, Takashi Iijima and Hiroyuki Sakamoto, P.W.R.I., Japan Ministry of Construction

RTAC Project - Summary Report on the Study of Additives and Extenders for Asphalt Cements, Dr. Ralph C.G. Haas, Pavement Management Systems, Paris, Ontario, et al

Coffee

Panel Discussion on Cooperative Research on Asphalt Additives and Extenders

- William A. Phang, Ontario MTC
- Dr. Ramph C.G. Haas, University of Waterloo
- Takashi Iijima, P.W.R.I., Japan MOC
- Dr. Teruo Sugarwara, Hokkaido University

4:00 p.m. - Closing Session: ARE FURTHER PHASES OF PAVING IN COLD AREAS PROJECT NEEDED? Peter Eggleton, Transport Canada, Transportation Development Centre, presiding

Thank you for supporting the workshop.

FIELD TRIP - THURSDAY, OCTOBER 21 (morning and afternoon)

8:00 a.m. - Field Trip, Don F. Martin, Paving Engineer, B.C. Ministry of Transportation and Highways, supervising

Assisted by:
Dick Callaghan, Surfacing Operations Superintendent
Ric Meidinger, Regional Manager, Paving, Kamloops
Bus transportation provided courtesy of Transport Canada, Transportation Development Centre.

Times listed below are approximate times.

October 21st

8:00 a.m.	- Leave Vancouver
10:00-10:30 a.m.	- COFFEE - Hope
11:00 a.m.	- 1982 Paving Project
12:00 noon-1:30 p.m.	- LUNCH - Princeton
1:30 p.m.	- Chem-Crete Test Section, near Keremeos
3:00-3:15 p.m.	- TEA - Penticton
5:30 p.m.	- Overnight at Vernon Lodge Inn, Vernon, B.C. Dinner at the hotel.

October 22nd

8:15 a.m.	- Leave Vernon
10:30-11:00 a.m.	- COFFEE - Adam's River
11:30 a.m.	- Transverse Crack Suppression Test Sections
12:30-1:30 p.m.	- LUNCH - Kamloops
2:00 p.m.	- Spencer Bridge
5:30 p.m.	- Hotel Vancouver

TECHNICAL APPENDIX B

LIST OF PARTICIPANTS

PAVING IN COLD AREAS - LIST OF PARTICIPANTS October 19, 1982

Professor Ken O. Anderson, Department of Civil Engineering, The University of Alberta, Edmonton, Alberta T6G 2G7

Mr. G.H. Argue, Airside Surfaces, Airport Facilities Branch, Transport Canada, Tower C, Place de Ville, Ottawa, Ontario K1A ON5

Mr. Murray Batten, Head, Quality Assurance Section, Construction Office, Ontario Ministry of Transportation and Communications, 355 Counter Street, Kingston, Ontario

Mr. R.H. Bjerke, Surfacing Standards Engineer, Alberta Transportation, 117 Grandin Village, St. Alberta, Alberta

Mr. John R. Callaghan, Surfacing Operation Superintendent, British Columbia Ministry of Transportation and Highways, 940 Blanshard Street, Victoria, British Columbia V8W 3E6

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TECHNICAL APPENDIX C

BACKGROUND DOCUMENT
FOR
FIELD TRIP

PAVING IN COLD AREAS

(Field Trip)

Thursday, October 21, 1982 - Field Inspection of Chem-Crete Asphalt Mix Test Section near Keremeos

Friday, October 22, 2982 - Field Inspection of Transverse Crack Suppression Test Sections near Kamloops

Report Prepared by: J.J. Meidinger
Regional Manager, Paving
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Report Presented by: B.C. Draper
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Kamloops

CHEM-CRETE TEST SECTION
1980
HIGHWAY 3 - BETWEEN HEDLAY AND KEREMEOS

Abstract

The construction of a test section using Chem-Crete bitumen was carried out with the objective of comparing the properties of Chem-Crete asphalt mix and the properties of the unmodified asphalt mix under field conditions.

Approximately 6 t of Chem-Crete bitumen was shipped from San Francisco and blended into the asphalt cement in the contractor's tanks at a ratio of one part Chem-Crete bitumen to nine parts asphalt cement. Approximately 1085 t of Chem-Crete asphalt mix was placed in two 37 mm lifts covering a total length of 1.14 lane kilometers.

Subsequent testing and observations of the field performance indicate that the Chem-Crete asphalt mix exhibits accelerated age hardening compared to the unmodified mix and severe cracking and disintegration began taking place within the first year of service.

Introduction

The Chem-Crete Corporation approached the B.C. Ministry of Transportation and Highways concerning the use of their Chem-Crete bitumen in asphalt concrete mixes. The bitumen was purportedly a product of a new refining technique that improved all the key properties of the asphalt such as stability, strength, durability, temperature susceptibility, fatigue life and water resistance. These improvements would also effect a reduction in initial cost because the pavement thickness could be reduced by as much as 40%.

The Ministry decided to construct two (2) test sections using the Chem-Crete bitumen, one section in the southern interior part of the province where the summer temperatures are very high and the other section in the northern interior where the winter temperatures are very cold.

This report is on the construction of a test section near Keremeos, B.C. in the hot southern interior of the province.

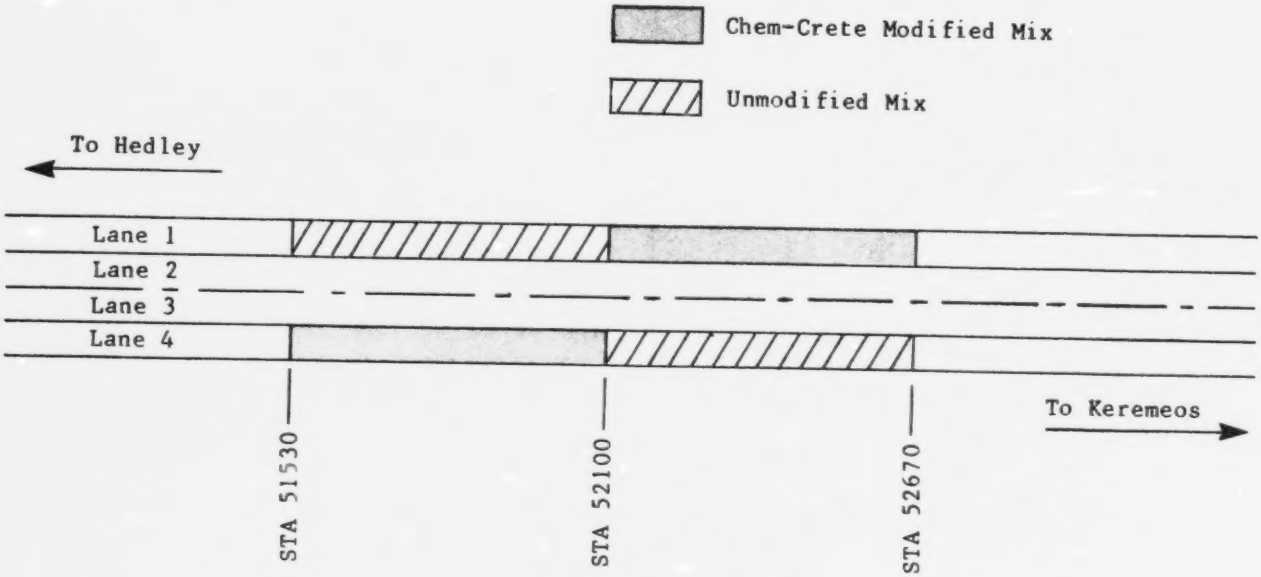
Test Section Location and Description

The section of B.C. Highway No. 3 being paved under the Ministry's Project S-792402 extended from 6.3 km west of Hedley to Keremeos.

The specific test section consnructed using Chem-Crete modified mix was a 1.14 km section of a 4-lane roadway some 13.6 km east of Hedley.

The test section was laid out as depected in Figure 1.

FIGURE 1



1) Lanes 2 and 3 were an existing 2-lane paved roadway.

2) Lanes 1 and 4 were newly constructed lanes using a conventional gravel base.

3) All four lanes were paved in two equal lifts for a total thickness of 75 mm.

Mix Design and Preliminary Work

The Ministry was advised by Chem-Crete Corporation not to change the design procedure for Chem-Crete modified mix. As a consequence, the following design was used for both the modified and unmodified mix:

Design Gradation

Sieve size	% by mass passing
16.0 mm	100.0
13.2 mm	88.7
9.5 mm	75.4
4.75 mm	56.0
2.36 mm	46.6
1.18 mm	40.7
0.600 mm	29.6
0.300 mm	15.0
0.150 mm	7.8
0.075 mm	5.1

Mix Design

Mixing Temperature	139 (137-142)°C
Compaction Temperature	128 (126-131)°C
Asphalt Content, percent	5.7
Bulk Relative Density, specimen	2.374
Bulk Relative Density, aggregate	2.677
Air Voids, percent	4.7
V.M.A., percent	16.1
V.M.A. filled, percent	70.3
Marshall Load, newtons	5902
Marshall Flow, hundredth of inch	6.8
Index of Retained Marshall Stability, percent	88.6
Asphalt Absorption, percent	0.617

Prior to any field work, a sample of IOCO AC-8 modified with 10% Chem-Crete bitumen was received for preliminary work.

The main findings were:

1. Modified Binder

   - % retained penetration after TFOT was low indicating a fast hardening product,
   - temperature susceptibility was unchanged,
   - slightly lower ductility,
   - recovered asphalt from briquettes allowed to cure for 28 days at 45°C was very hard.

2. Modified Mix

   - stability of specimens allowed to cure for 28 days at 45°C was 70% higher,
   - slightly higher flow index,
   - retained Marshall Stability remained unchanged.

Test Section Construction

The Chem-Crete binder was delivered by tanker truck from San Francisco on June 10, 1980. Approximately 6.16 t was pumped off for this test section and the other 11.49 t continued on to Fort St. John, the site of the second test section. The Chem-Crete modified asphalt was made by mixing one part Chem-Crete bitumen to nine parts Imperial AC-8.

The bottom lift of the test section was constructed on June 11, 1980 under ideal weather conditions. There were 441 t of modified mix placed that day in the test section.

The top lift of the test section was constructed June 23, 1980 under ideal weather conditions. There were 644 t of modified mix placed in the test section that day.

All quality control tests and measurements indicated a consistent mix produced very close to the design requirements.

Modified Mix Analysis

During the construction, 24 asphalt samples were gathered for testing. The results are contained in Table 1.

During the construction, 22 compacted specimens were prepared and the results are contained in Table 2.

During the construction, 38 cores were drilled and the results are contained in Table 3.

Some of the more important observations and test results were as follows:

Freshly laid Chem-Crete mix has 7.5% lower stability than the unmodified mix. It also has a 5.5% lower Marshall Flow Index.

After 28 days of curing at 60°C in air bath, the unmodified mix gained only 20.6% stability while the Chem-Crete modified mix gained 88.7% stability. There is a 33.8% increase in Flow Index by curing Chem-Crete mix.

Unmodified AC-8 (control section) asphalt after 28 days of curing at 60°C in air bath still has a penetration of 37-42 at 25°C. AC in the pavement will arrive to this stage in about 6-10 years.

Chem-Crete modified asphalt after 28 days of curing at 60°C in air bath has a low penetration of 19-21 at 25°C. A pavement with unmodified AC would break up at this low penetration stage.

Binder in the freshly laid Chem-Crete section has the same degree of hardness (aging) as unmodified binder after 8-12 years of road service.

There is no difference in the critical temperature (Tc) between modified and unmodified products.

The ductility of Chem-Crete modified asphalt drops drastically (from +145 to 21 and 27) after 28 days of curing at 60°C.

Structural Capacity Analysis

Testing of the surface rebound was done with a Benkelman Beam on the gravel prior to paving, on the pavement immediately after completion,

and four times since on July 25, 1980, October 28, 1980, April 30, 1981 and September 8, 1981.

The primary conclusion as a result of this testing is that Chem-Crete modified mix has no effect on the surface rebound of the roadway.

Post Construction Field Observations

Cracking, extreme wear and some disintigration were evident by January 1981, only seven months after the test section was constructed.

The Chem-Crete modified mix looked like it had aged (hardened) prematurely, resulting in random cracking, wear and ravelling.

The surface continues to deteriorate at a much more rapid rate than the unmodified mix.

References

1. J. Sam, Jr., "Chem-Crete Test Section - Field Report," 1980.

2. B. Varady, "Final Report on Chem-Crete Test Section, Keremeos,", 1980.

3. J.D. Mewhort, "Preliminary Report on Test Sections - Paving Project 2402 - Chem-Crete," 1980.

S-792402, KEREMEOS TEST SECTION
TABLE OF BINDER TEST REPORT

	VISCOSITY @135°C	VISCOSITY @60°C	PENETRATION @25°C	PENETRATION @15.6°C	PENETRATION @10°C	Tc	% RETAINED PENETRATION @25°C	DUCTILITY @25°C
Control Section, AC-8 Ioco, Unmodified								
Bottom Lift								
Original AC	216	817	82	22	10.5		100.0	+145
After TFOT	299	1626	52	18	9.0	-25	63.4	+145
After just laid	292	1544	58	19	10.0	-27	70.7	+145
After 28 days curing @ 60°C air bath	393	3069	37	15	8.0	-28	45.1	+145
Top Lift								
Original Ac	212	726	83	24	12.0		100.0	+145
After TFOT	273	1427	53	17	9.5	-27	63.9	+145
After just laid	237	1313	65	21	11.0	-28	78.3	+145
After 28 days curing @ 60°C air bath	343	2622	42	16	9.0	-29	50.6	+145
Chem-Crete, Modified AC-8								
Bottom Lift								
Original AC	195	560	105	28	13.0		100.0	+145
After TFOT	290	1686	56	19	10.0	-28	53.3	+145
After just laid	369	3575	38	15	8.5	-29	36.2	+145
After 28 days curing @ 60° air bath	613	13256	21	10	6.0	-30	20.0	27
Top Lift								
Original AC	189	512	120	32	14.0		100.0	+145
After TFOT	301	1658	56	19	10.0	-28	46.7	+145
After just laid	510	7628	32	12	8.0	-30	23.3	+145
After 28 days curing @ 60° air bath	720	20069	19	9	5.5	-29	15.8	21

Note: 1. "After just laid" results are on recovered binder from fresh pavement.
2. "After 28 days curing" results are on binder recovered from briquettes after 28 days of curing.

TABLE 1

S-792402, KEREMEOS TEST SECTION
TABLE OF PLANT BRIQUETTES

	Control Section		Chem-Crete Section	
	Bottom Lift	Top Lift	Bottom Lift	Top Lift
Standard Procedure				
Relative Density	2.420	2.425	2.424	2.423
Marshall Stability, N	7311	7040	6648	6614
Marshall Flow, 1/100"	8.1	8.2	8.0	7.4
After 28 Days Curing @ 60°C Air Bath				
Relative Density	2.421	2.426	2.426	2.425
Marshall Stability, N	8388	8917	11912	13116
Marshall Flow, 1/100"	7.2	8.3	10.2	10.4

Note: 1. Each result shown above represents the average of three specimens, each of them were made at a different time.

2. Plant briquettes for bottom list were made on the 13th of June, 1980 for top lift on the 23rd of June, 1980.

TABLE 2

S-792402, KEREMEOS TEST SECTION
TABLE OF ROAD CORES

	Depth of Pavement	Relative Density	Degree of Compaction	% Road Density
Control Section				
Bottom Lift	1.5"	2.309	95.4	96.7
Top Lift	2.0"	2.313	95.4	96.9
Chem-Crete Section				
Bottom Lift	1.6"	2.345	96.7	98.2
Top Lift	2.0"	2.314	95.5	96.9

Note: 18 cores were drilled on the top list and 20 cores on the bottom lift of pavement for density and recovery purposes.

TABLE 3

TRANSVERSE CRACK SUPPRESSION TEST SECTIONS
HIGHWAY 97 - VICINITY OF MONTE LAKE

Abstract

In-place cole mix recycling and placement of reinforcing geotextile fabric were carried out with the objective of reducing or prohibiting reflective transverse cracking in the new pavement.

The in-place cold recycling was performed on grindings from a milling machine by adding Cyclogen ME rejuvenating agent, HF500(M) high float mixing grade emulsion, and HF500(M) plus 40% new aggregate in three test sections. The two HF500(M) recycling sections were judged to be the best quality recycled asphalt base course on which to place the hot mix recap.

Both the woven polypropylene and non-woven polyestr types of geotextile from three manufacturers were used. the non-woven polyester was judged to be the easiest fabric to install because it had less tendency to wrinkle.

The success, if any, of all the test sections in reducing reflective cracking is yet to be ascertained and will be the subject of further monitoring and future appendices to this report.

Introduction

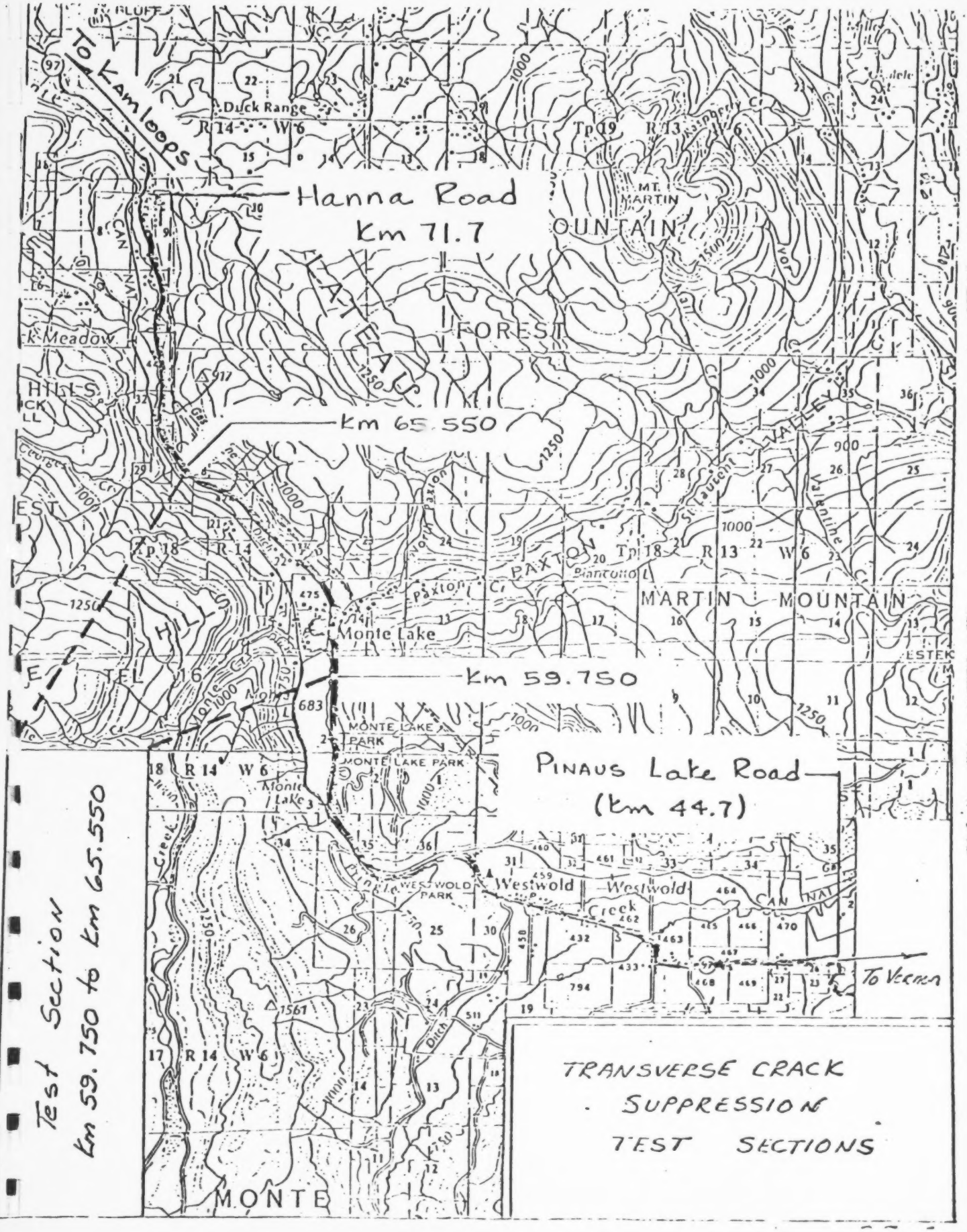
A section of the Vernon-Kamloops Highway 97, which had been previously paved in 1970, had deteriorated to a point in 1980 that an asphalt concrete overlay was planned and tendered for the summer of 1981 under the Ministry's Contract S-0645.

The specific section involved was from Pinaus Lake Road at Km 44.7 to Hanna Road at Km 71.7 (27 km). (See Figure 1.)

There were future plans to reconstruct the said section within the next 10 years, so the Ministry decided to repave the roadway with a single 50 mm lift of asphalt pavement now to maintain the surface in an acceptable condition for the 10 year period.

The existing 1970 pavement which had been chip sealed in 1971 was characterized by numerous close interval transverse temperature cracks which had begun to spall at the crack in the wheelpaths. The patching on this section of highway had reached an unacceptably high level by about 1979.

It was recognized that with the planned thin overlay (50 mm) on such a badly cracked roadway, reflection cracking in the new overlay would be a certainty and would, therefore, afford the Ministry an excellent opportunity to field test different techniques that purportedly suppressed the reflection of the transverse temperature cracks in the underlying asphalt through into the new asphalt mat.


To Kamloops
Duck Range
R 14 W 6
Tp 19 R 13
Hanna Road
Km 71.7
MT. MARTIN
MARTIN MOUNTAIN
FOREST
Km 65.550
Tp 18 R 14 W 6
Tp 18 R 13 W 6
PAXTON
Paxton Cr
Monte Lake
MARTIN MOUNTAIN
Km 59.750
MONTE LAKE PARK
Pinaus Lake Road
(km 44.7)
Westwold
Westwold Creek
CANNAT
To Vernon
Test Section
Km 59.750 to Km 65.550
TRANSVERSE CRACK
SUPPRESSION
TEST SECTIONS
MONTE

Test Section Description and Location

The section chosen for all the crack suppression test sections was a 5.8 km section of Highway 97 that started about 1 km south of the Village of Monte Lake and went northerly for approximately 4.8 km. The individual sections are described as follows:

Section A - Reinforcing Fabric Test Section

Km 59.750 to Km 62.55 (2.8 km)

Section B - In-place Cold Recycle Test Section

Km 62.950 to Km 63.790 (0.84 km)

Section C - Control Section with No Suppression Technique

Km 63.790 to Km 65.550 (1.76 km)

*Km 61.00 - intersection of Paxton Valley Road and Highway 97 in the Village of Monte Creek.

The test sections are not of equal length, nor are they continuous because the test section lengths had to be changed due to availability of necessary materials.

See Figure 2 for key plan showing location of test sections.

The section was chosen as it was considered average in transverse crack frequency and average in severity of crack disintegration and the topography lent itself to low level flying, which was done to photo-record the exsiting cracks.

Test Section Preparation

Photo Record

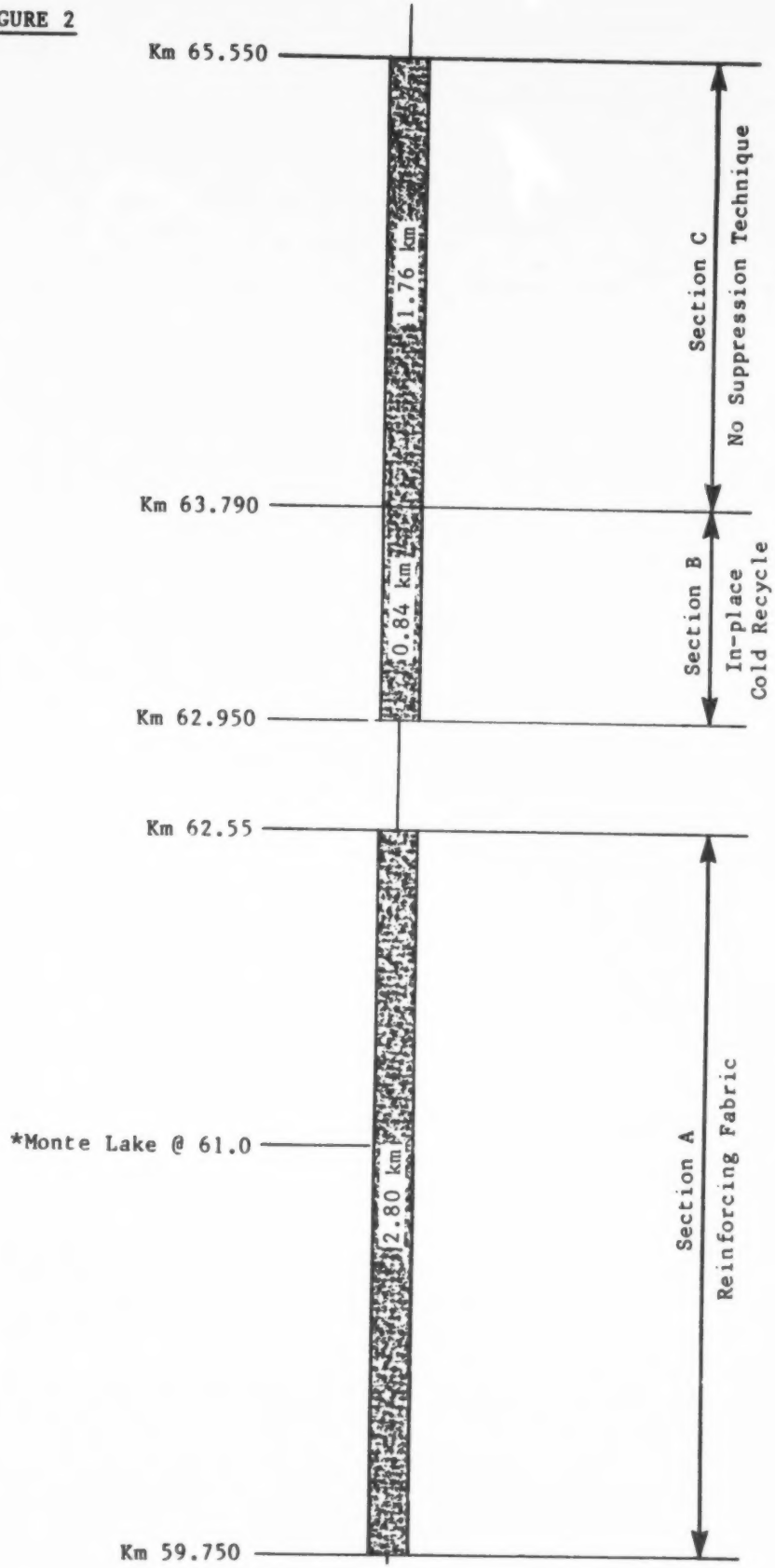
The whole length of the test section from Km 59.750 to Km 65.550 was flown in the spring of 1981 to photo-record the transverse cracks in the existing pavement to be overlayed. The section will be flown each year after to photo-record the resurgence of the reflective cracking as it occurs.

Crack Filling

Test Sections A and C received a crack filling treatment.

Originally, all cracks were going to be filled with an HF150(S) emulsion asphalt and binded with a sharp fine sand. A hand sprayer on a distributor truck was used to spray the HF150(S). Problems occurred almost immediately with HF150(S) breaking in the distributor and spraying equipment, so only about 1/2 the cracks got filled with HF150(S). Of the ones that were filled, many had the asphalt picked out by vehicle tires before paving occurred.

FIGURE 2


Km 65.550
1.76 km
Section C
No Suppression Technique
Km 63.790
0.84 km
Section B
In-place
Cold Recycle
Km 62.950
Km 62.55
*Monte Lake @ 61.0
2.80 km
Section A
Reinforcing Fabric
Km 59.750

As a consequence, all cracks including cracks that had been filled with HF150(S) were filled with fine asphalt mix by hand placing methods prior to paving. The fine mix was compacted with a small roller.

Crack Counts

In addition to the photo log, all cracks were referenced by mathematical station, classified by type and counted in number.

The following table summarizes the number of cracks by type.

SPRING 1981 TRANSVERSE THERMAL CRACK COUNTS

Type 1 - Transverse Crack 0.6 m Length 3.0 m
Type 2 - Transverse Crack Length 3.0 m

		NUMBER			FREQUENCY (No/km)		
SECTION	STA to STA	Type 1	Type 2	Total	Type 1	Type 2	Total
Fabric Test Section A	59.750 to 62.550 (2.8 km)	43	302	344	15	108	123
Cold Mix Recycle Section B	62.950 to 63.790 (0.84 km)	9	57	66	11	68	79
Control	63.790 to 65.550 (1.76 km)	12	126	138	7	72	78
Average	5.4 km			548			101

Test Section A - Reinforcing Fabric Test Section

Because the Ministry had no experience with installing geotextiles, some experimenting with metre square test patches prior to the main installation was carried out to ascertain the best bonding agent and at what application rate. Asphalt emulsion RS-2k at an application rate of 0.75 l/m^2 was chosen.

The fabrics were placed as depicted in Figure 3, using a shop made fabric laydown machine, from July 13 to 16, 1981.

The following summary comments are made about each of the four (4) fabrics installed:

1. Synflex Permaliner 2006 (Woven)

   - This was the strongest of the fabrics used.

- There was some wrinkling and buckling of fabric during placement, expecially on curves.

- The asphalt mix tended to check and crack immediately behind the screed and during compaction, probably because the facric is very smooth.

2. Synflex Permaliner 4545 (Non-woven)

- There was some wrinkling of fabric, especially on curves.

- There was no problem with checking and cracking of the asphalt mat.

3. Du Pont "Reepav" (Non-woven)

- Only 100 yards of this fabric was laid.

- The asphalt mix checked and cracked when rolled.

- The texture is like a thin cardboard.

- Not enough was installed to make and firm conclusions.

4. Crown Zellerback "Petromat" (Non-woven)

- Only 215 yards of this fabric was laid.

- It is very similar in appearance and texture to Synflex Permaliner 4545.

- It is lower in strength than Synflex 4545.

- This was the least wrinkling of all fabrics.

- There was very little wrinkling on tangent or curve.

Test Section B - Cold Recycle Test Section

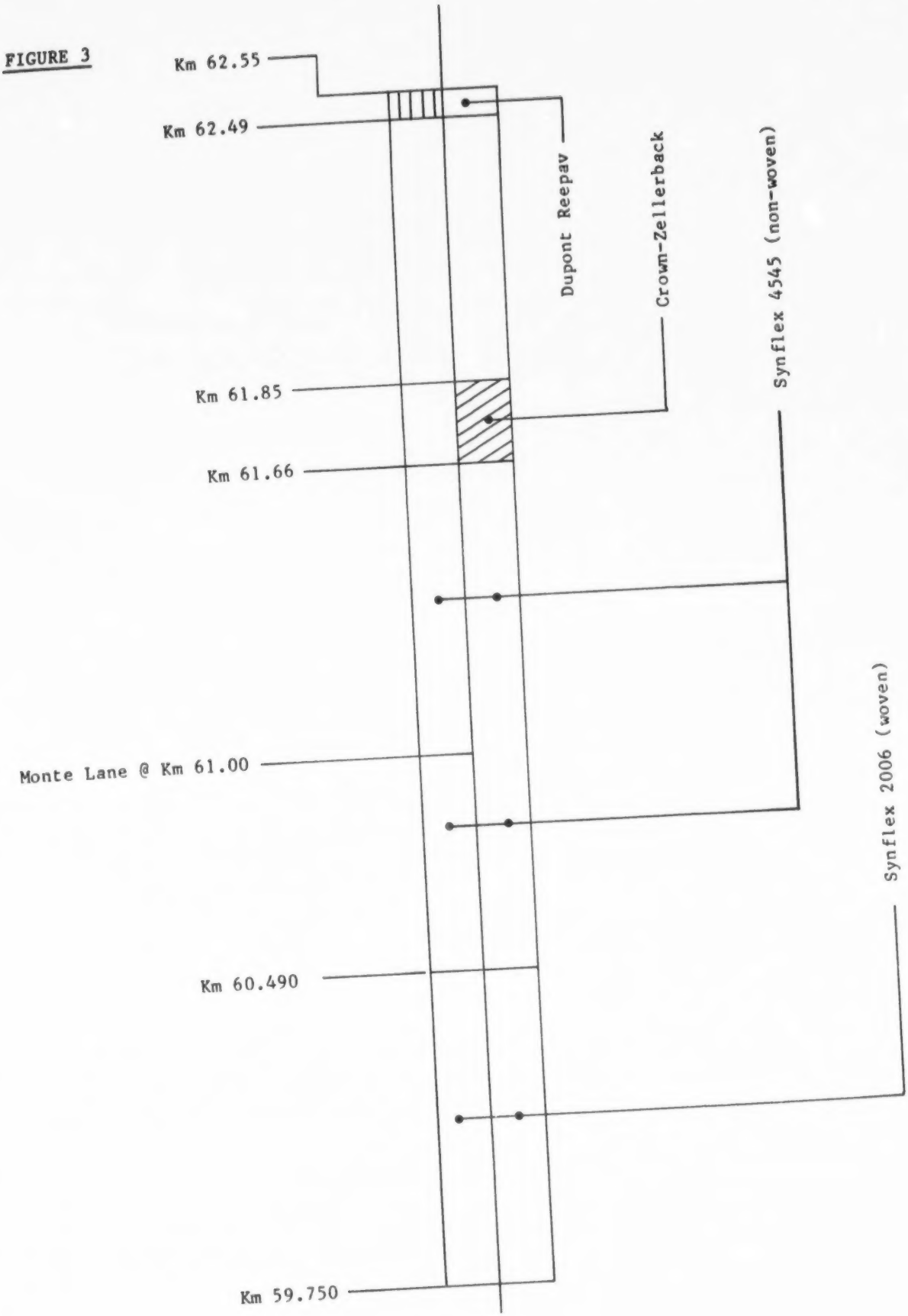
1. Test Section Layout

The in-place cold recycle was done using three (3) different methods. The roadway was milled with a grinding machine full width (7.3 m) to a depth of 50 mm and the cuttings were windrowed on one shoulder of the road. The widrowed cuttings were reprocessed as follows:

a) Section No. B-1 (Km 62.95 to Km 63.080) - 120 m

Using Cyclogen ME, which is an emulsified rejuvenating agent. The supplier was Witco Chemical Canada Ltd. at a cost of $1.14/ litre (1981 dollars) f.o.b. job site. This was shipped in 200 l containers.

FIGURE 3


Km 62.55
Km 62.49
Dupont Reepav
Crown-Zellerback
Synflex 4545 (non-woven)
Km 61.85
Km 61.66
Monte Lane @ Km 61.00
Synflex 2006 (woven)
Km 60.490
Km 59.750

The length of Section No. B-1 is only 120 m, which is considered to be too short to be of great value, but this length was fixed as we had only ordered 2200 l of Cyclogen and this 2200 l would only cover approximately 120 m at the design application rate.

b) Section No. B-2 (Km 63.070 to Km 63.450) - 380 m

Using HF500(M) which is a high float emulsified mixing grade emulsion asphalt at a cost of $0.2296/litre (1981 dollars) f.o.b. job site. This material was supplied by Pounder Emulsions Group from their plant in Kamloops and delivered to the job site by tank truck.

c) Section No. B-3 (Km 63.450 to Km 63.790) - 340 m

Using the HF500(M) as in Section No. B-2, but adding 40% new aggregate to recycle windrow.

The length of Sections No. B-2 and B-3 were set at approximately 300 m, as it was felt that 300 m was a minimum length to evaluate results properly and there was a real desire to minimize the length of the recycle because of the possible negative consequences of a stability failure on Highway 97 in July with a summer traffic volume of 4300 ADT (1980 count).

See Figure 4 for a key plan showing the location of the three cold recycle test sections.

2. In-place Recycle Construction

The major objectives that were set for the in-place recycled mix were:

a) ability to resist plastic deformation (rutting) under imposed loading throughout its design life,

b) to remain intact under all weather and traffic conditions from the time of final compaction to overlay by hot mix,

and these objectives were to be met at the lowest possible rejuvenator content, hence the lowest cost possible.

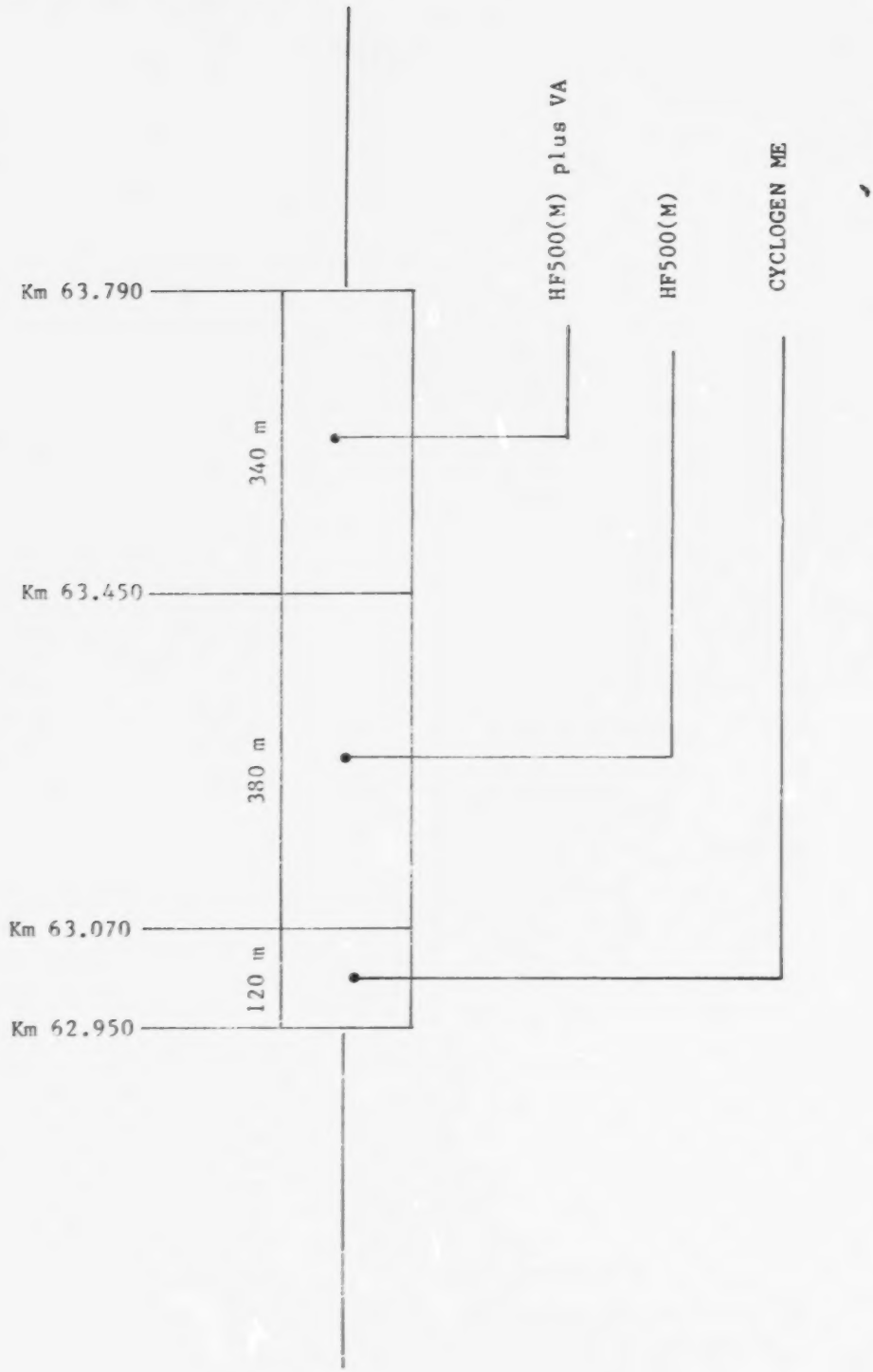
The quantities actually applied are as follows:

a) Cyclogen ME

Design 2103 l (2.5%)		
Applied July 1, 1981	=	2150 l
Applied July 2, 1981	=	nil
Total	=	3250 l

Applied percentage = 2.6% by weight of cuttings

FIGURE 4


HF500(M) plus VA
HF500(M)
CYCLOGEN ME
Km 63.790
Km 63.450
Km 63.070
Km 62.950
340 m
380 m
120 m

b) HF500(M)

Design 7656 l (2.3%)
Applied July 1, 1981 = 5945 l
Applied July 2, 1981 = 741 l
Total = 6686 l

Applied percentage = 2.0% by weight of cuttings

c) HF500(M)/VA

Design 13 991 l (3.8%)
Applied July 1, 1981 = 5320 l
Applied July 2, 1981 = 663 l
= 870 l
Total = 6853 l

Applied percentage = 1.9% by weight of cuttings plus virgin aggregate

More HF 500(M) was not added, even though the design percentage had not been achieved, because it was felt that the recycled mix met all the objectives as set out above, and adding more rejuvenator (HF500(M)) would simply increase the cost with little or no improvement in quality.

The cold recycled mix obtained in all three sections met the objectives, namely:

They did not deform plastically under imposed loading and they remained intact until top lift hot-mix recap was placed on July 13, 1981 and it did this at the lowest rejuvenator content which was deemed feasible.

Test Section Observations

Transverse Crack Counts done in spring 1982 are as follows:

Section A - Fabric

Synflex 2006 - 62.6% of cracks returned
Synflex 4545 - 72.5% of cracks returned

Section B - Recycle

Whole Section - 28.8% of cracks returned

Section C - Control Section

Whole Section - 91.3% of cracks returned

References

1. J.F. Meidinger, "Transverse Crack Suppression Test Sections - 1981 - Highway 97 in Vicinity of Monte Lake," 1982.

TECHNICAL APPENDIX D

RECORD OF DISCUSSION

CANADA/JAPAN SCIENCE AND TECHNOLOGY CONSULTATIONS

PAVING IN COLD AREAS
Mini-workshop
October 18-22, 1982
Vancouver, British Columbia

Record of Discussion

The mini-workshop achieved totally its objective of being the forum whereby information was exchanged on research and experience in Canada and Japan on the subject of "Paving in Cold Areas". The workshop was attended by 17 Japanese and 28 Canadians from a broad cross section of university, private sector, governmental and regional organizations. The workshop proceedings recorded the seven Japanese and 15 Canadian papers presented. Productive discussions were held to identify areas and mechanisms for subsequent cooperation.

The workshop participants from both countries agreed that it was a highly worthwhile experience and the knowledge gained was of benefit to each side. The formal presentations and proceedings were complemented by a field trip over highways in the Coast Range Mountains, Okanagan and Fraser Canyon regions of British Columbia. Several test and special sections of the highway were inspected first-hand, reinforcing direct knowledge of the techniques in use and being investigated in British Columbia to alleviate problems experienced with highway paving in cold areas.

There was a consensus that another workshop two to three years in the future in Japan was highly desirable.

Several areas for specific cooperative research were identified. The ones receiving highest priority included:

1) the use of additives in asphalt to improve the resistance of pavements to cold area problems such as rutting, studded tire wear and control of reflection cracking,

2) uniform measurement techniques and the development of appropriate criteria pertaining to the quality of pavement service,

3) automated data collection and analysis for decision-making in pavement management, and

4) techniques and materials to minimize and cure the effects of pavement cracking in cold areas, more specifically, reflection cracking.

Through the designated national contact officers, it was agreed that specific cooperative activities and projects would be identified in more detail and the implementation procedure would be pursued.

It was foreseen that cooperative projects requiring extensive resource commitment and more formal arrangements would be the subject of Joint Research Project Agreements.